Submitted: Oct 04, 2025 | Accepted: Dec 20, 2025
Vol. 8/No. 2/July-December, 2025 Original Article

A Comparative Study of Freeway Space Measured in Dentulous Patient With and Without Head Stabilizing Device

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ABSTRACT

Introduction: Freeway space is described as the space between the maxillary and mandibular teeth when the mandible is in the natural or physiological rest position. The incorrect measurement of freeway space can lead to bruxism of teeth, difficulties in creating the lip seal, artificial appearance, cheek biting, angular cheilitis, temporomandibular joint pain etc. The physiological rest position of the mandible is widely used in clinical practice as a functional method for the determination of freeway space. However, the mandibular position is considered to be affected by various factors such as head and body postures. Thus, the purpose of this study is to determine and compare the average freeway space in dentate subjects with and without head stabilization.

Methods: The total sample of 81 adult patients with the age range of 18-35 years were taken. Vertical dimension at rest and Vertical dimension at occlusion were measured with and without head stabilization and freeway space value was calculated. Paired sample t-test was used to compare the freeway space with head stabilization and without head stabilization.

Results: The mean freeway space with head stabilization and without head stabilization was 2.72 + 1.25 mm and 2.52 + 1.32 mm respectively. There was no statistically significant difference in the freeway space with and without head stabilization.

Conclusion: The freeway space in dentate adults range from 1-6 mm. There is no evidence to support that FWS values obtained after head stabilization is close to the recommended range of FWS compared to the values obtained without stabilizing head.

Keywords: Freeway space, Head posture, Head stabilizing device, Vertical Dimension

INTRODUCTION

In the realm of Prosthodontics and dental care, the concept of freeway space (FWS) has been a pivotal subject for understanding optimal jaw positioning and bite balance. Every individual with their natural dentition presents freeway space, which is the space between the maxillary and mandibular teeth when the mandible is in the natural or physiologic rest position.[1] FWS is the difference between the rest vertical dimension (VDR) and the occlusal vertical dimension (VDO).[2] FWS is a key factor in assessing an individual's ability to perform oral functions, in maintaining aesthetic balance during oral reconstructive procedures and is equally significant across various dental specialities.[3]

Determining the VDO is especially crucial in the success of complete dentures, partial dentures, or where a new occlusion must be created. One of the effective methods for establishing the

Conflict of Interest: None

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correct VDO is by measuring the interocclusal rest space. This is important because, after activities like chewing and speaking, an adequate interocclusal rest space allows the muscles to return to their resting length.[4]

Various methods of measuring OVD in dentulous and edentulous patients are pre-extraction records, physiological rest position, phonetics, esthetics, swallowing threshold, radiographic methods, anthropometric methods, Electromyography etc.[5–8] But no any single method is universally accepted and superior over another. Most studies suggest that an optimal interocclusal rest space value is between 2 to 4 mm. However, research across various population has shown that the IRS can vary significantly, ranging from 0.5 to 7 mm.[4,9–11]

Freeway space has also been defined as the neutral position achieved by the mandible when it is involuntarily suspended by the mutual coordination of the elevator and depressor masticatory muscles with the maxillary and mandibular teeth separated. When the normal space is invaded, the masticatory muscles' stretch reflex is constantly overstimulated, causing excessive contractions of the muscles. This, in turn, affects the temporomandibular joint, teeth, periodontium, and supporting tissues. As a result, the alveolar bone is sacrificed in order to establish appropriate FWS. However, allowing too much room puts the masticatory muscles at significant risk.[12]

The amount of FWS in any individual is mainly an expression of muscle function, its equilibrium and gravity.[13] When the tension created by the muscles of mastication that elevate the mandible above is in equilibrium with the tension of the musculature that depress the mandible from below and gravity, then the mandible will be theoretically at rest.[14] The physiological rest position of the mandible is widely used in clinical practice as a functional method for the determination of freeway space. However, the mandibular position is considered to be affected by various factors such as head and body postures, mental state of subject, function of masticatory and facial muscles and temporomandibular disorder.[15]

While prior studies report FWS variability (1-7 mm) influenced by head posture and methods like swallowing or phonetics, evidence remains inconsistent on whether head stabilization improves measurement accuracy in dentulous adults. One study directly compare FWS with and without head stabilization, leaving uncertainty about its clinical utility for prosthetic vertical dimension determination. [16] Thus, this study addresses this gap by evaluating FWS variations using modified head stabilizing device in Nepalese dentulous patients. Additionally, this study ascertains the average freeway space of dentate subjects and to take these values into account when fabricating the prosthesis for edentulous patients to improve the prosthesis's outcome.

ALTERNATIVE HYPOTHESIS

There is a significant difference in mean Freeway space value obtained with and without head stabilization.

METHODS

An observational, cross-sectional study was conducted in Nepalese adult patients visiting Chitwan Medical College - School of Dental Science (CMC-SODS) for diagnosis and treatment. The research was conducted in the Department of Prosthodontics and Maxillofacial Prosthetics of CMC-SODS from March 2023 to Aug 2024. A non-probability convenience sampling method was used to meet the selection criteria.

Inclusion criteria

- Dentulous patient having a full complement of teeth (Third molar may be present or absent).

- Patients who agree to participate in the study and give written consent.
- Patients with class I skeletal relation and class I molar relation.

Exclusion criteria

- Patients having history of extraction or orthodontic treatment.
- Patients showing signs and symptoms of Temporomandibular Joint Disease.
- Patients with prior history of trauma and facial asymmetries.
- Patient with craniofacial abnormalities and those who have undergone surgeries.
- Patients showing psychological and behavioral disorder

A written consent was taken from the subjects to participate in the study. There was total 81 patients included in the study. Ethical approval was obtained from Institutional Review committee of Chitwan Medical College.

Detailed history of the patient was taken to find out reasonable risk factors. Informed and written consent were taken from patient and after that, clinical examination was performed and only the patient fulfilling inclusion criteria were included in the study. Readings were taken in the early morning to avoid the chances of muscle fatigue.

The subjects were seated comfortably in the dental chair in upright position with head unsupported and keeping the Frankfort horizontal (FH) plane parallel to floor. Triangular piece of adhesive tapes was sticked on the reference points, tip of the nose and the most prominent part of soft tissue of chin, and small circles of approximately 0.2 mm in diameter were marked on these tapes with pen.

Subjects were asked to bring the teeth together in maximum intercuspation. The tips of the vernier calipers (INGCO, China) were placed in the circles marked earlier as shown in figure 1. This gave the vertical dimension at occlusion. The subjects were relaxed and measurements for VDR were taken (Figure 2). Readings were taken 5 times for both measurements. The average of 5 measurements of rest position and maximum intercuspation were taken. The freeway space was calculated by subtracting the above two average values.

With head stabilizing device

A head posture-fixing device was modified in the Department of Prosthodontics, School of Dental Sciences, Chitwan Medical College (Figure 3). The construction and design of device is as follow: a plywood of 10 mm thickness was taken and cut into two equal rectangular pieces of dimension 26mm×19mm. They were covered by silver wrapping paper to make more esthetic. The two pieces were connected together with the help of hollow metallic tube on both sides which were again connected with flat metal piece on the top and it was metal welded. A metal bushing sleeves and metallic screw welded together was used to attach the hollow metal tube and plywoods in the outer side of the device and ear piece and plywood in the inner side of device. Ear piece was used to stabilize the ear. For fitting in different head circumference, device was spring loaded on the top. The different components were assembled together.

Each subject was asked to sit in the dental chair in same position as earlier. The head posture fixing device was used to fix the head posture in a natural head position. The device was placed in the head such that the lower end of each plywoods would touch the shoulder of the subject as shown in figure 4. The device was tightened with metal bushing sleeve placed on both sides to fit in the different head circumference. The goniometer (360°) axis (National, India) was used to cross-check whether the position was correct or not. It was centered over the external acoustic meatus of right ear with the fixed

arm held vertical, whereas the movable arm in alignment with pupillary line and parallel to base of mandible to check the head position as shown in Figure 5.

Next, the measurements for vertical dimension at rest and vertical dimension at occlusion was obtained by similar method described earlier using same vernier caliper. Then freeway space was calculated. All the measurements and observation were done by a single observer. To determine the intra-observer reliability, the measurements were repeated five times for each reading and average of the readings was noted as the final reading. Patient was first demonstrated how to sit in position and practice swallowing and relaxing and then patient was asked to practice the procedure twice before taking the actual readings. Reliability of Vernier caliper was checked by measuring the length of known object for example, measuring scale. The reliability of head stabilizing device was assessed through intra-observer repeatability by verifying goniometer angles five times per subject. Validity was confirmed by aligning the FH plane parallel to the floor, verified via goniometer by keeping fixed arm vertical and movable arm along pupillary line, consistent with natural head position protocols in prior studies.[16] No inter-observer calibration was performed due to single-operator design

Statistical analysis

The statistical analyses were performed using the Statistical Package for the Social Science (SPSS) version 27. For descriptive statistics; frequency, mean, standard deviation, maximum value, and minimum value were assessed. A paired sample t-test was used to compare the freeway space with head stabilization and freeway space without head stabilization. An independent sample t-test was done for comparison of freeway space based on gender.

RESULTS

This cross-sectional observational study was conducted on 81 participants (34 males, 47 females) during the study of 1.5 years. The age of the patients was in the range of 18-35 years. The mean FWS with head stabilization (HS) was 2.72±1.25 mm. Likewise, mean FWS without head stabilization was 2.52±1.32 mm. The outcome of the study was evaluated using a paired sample t-test. There was no statistically significant difference in FWS with and without head stabilization with p value of 0.226 (95% CI:-0.12,0.50) as shown in Table 1.

The mean vertical dimension at rest (VDR) was observed to be 59.39±7.05 mm with head stabilization and 59.15±7.33 mm without head stabilization. Similarly, the mean vertical dimension at occlusion (VDO) was found to be 56.72±7.17 mm with head stabilization and 56.67±7.38 mm without head stabilization as shown in Table 2. Also, the table shows the comparison of VDR with and without head stabilization and VDO with and without head stabilization. Both of the comparisons showed no statistically significant difference with p value of 0.389 (95%CI: -0.31,0.79) and 0.863 (95%CI: -0.52, 0.62) respectively.

Table 3 shows descriptive data for FWS with and without head stabilization based on gender and their comparison using independent sample t-test. Freeway space in females with head stabilization was 2.6±1.2 mm and without head stabilization was 2.2±1.12 mm. Likewise, among males the FWS value with HS was 2.88±1.31mm and without HS was 2.85±1.5 mm. There was no statistically significant difference in the FWS values obtained with and without head stabilization on both males and females.

Figure 1: *Vertical dimension at occlusion measured using Vernier caliper*

Figure 2: *Vertical dimension at rest measured using Vernier caliper*

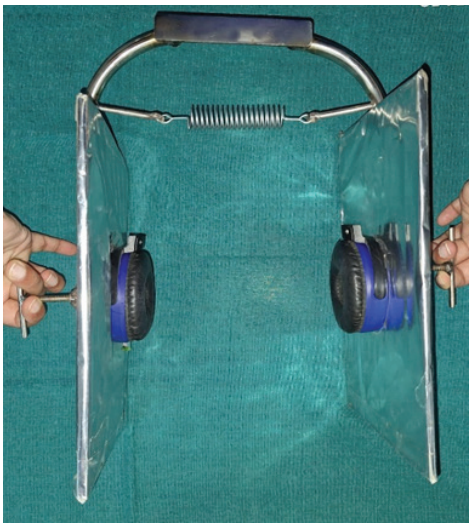

Figure 3: *Head stabilization device*

Figure 4: *Measuring freeway space using Head stabilizing device - frontal view*

Figure 5: *Horizontal arm of Goniometer axis passing through pupillary line and parallel to base of mandible.*

Table 1: Mean, Standard deviation, Maximum value, Minimum value and comparison of freeway space with and without head stabilization

Parameter	Mean ± SD (mm)	Minimum (mm)	Maximum (mm)	P value
FWS with HS	2.72 ± 1.25	1	6	0.226
FWS without HS	2.52 ± 1.32	1	5	

*: p-value <0.05 considered statistically significant

Table 2: Mean, Standard deviation, Maximum value, Minimum value and comparison of VDR and VDO with and without head stabilization

Parameter	Mean ± SD (mm)	Minimum (mm)	Maximum (mm)	P value
VDR with HS	59.39 ± 7.05	42	75	0.389
VDR without HS	59.15 ± 7.33	40	73.5	
VDO with HS	56.72 ± 7.17	42	77	0.863
VDO without HS	56.67 ± 7.38	40	75	

*: p-value <0.05 considered statistically significant

Table 3: Mean, Standard deviation, minimum value, maximum value and comparison of FWS with and without head stabilization based on gender

Gender	Parameter	Mean ± SD (mm)	Minimum (mm)	Maximum (mm)	P value
Female	FWS with HS	2.6 ± 1.2	1	5	0.126
	FWS without HS	2.2 ± 1.12	1	5	
Male	FWS with HS	2.88 ± 1.31	1	6	0.909
	FWS without HS	2.85 ± 1.5	1	5	

*: p-value <0.05 will be considered statistically significant

DISCUSSION

Freeway space is an important parameter in Prosthodontics to ensure the success of complete denture through its function and comfort. Various methods of measuring freeway space in edentulous patients are pre-extraction records, physiological rest position, phonetics, esthetics, swallowing threshold, etc. While recording the jaw relation in the process of fabrication of complete denture, VDR and VDO is measured clinically using different methods with the occlusal rim placed intraorally. The occlusal rims are adjusted till then, such that a freeway space of recommended range is created. Different authors recommend different range of FWS for edentulous patients. Hence this study was conducted to find the range of freeway space in dentate individuals so that it could be utilized to create FWS in edentulous patients.

The physiological rest position of the mandible is most widely used in clinical practice as a functional method for the determination of freeway space. However, the mandibular position is considered to be affected by various factors one of which is head and body postures. Research has shown excellent reproducibility of freeway space obtained after head stabilization in comparison to without head stabilization.[16] However, there are not enough studies to support the statement. Therefore this study was conducted with the main aim of evaluating FWS variations using modified head stabilizing device.

This study was based on the hypothesis that the FWS value obtained after head stabilization is more accurate than the values without stabilizing the head. The result of this study does not support the hypothesis, the result being statistically not significant. This study contradicts with the study of Mishra et al. (2019) whose result showed excellent reproducibility of FWS value after fixing the head in the natural head position with head stabilizing device, the result being statistically significant.[16] The difference in the results of these two studies could be attributed to a very small sample size taken in the earlier study.

In a study conducted by Samejo et al. (2013) where freeway space was measured with Willis gauge and sprung divider, the sprung divider showed more accuracy than Willis gauge, however the result being not statistically significant. They determined the FWS value in the range of 2-7 mm using Willis gauge and 2-6 mm with sprung divider.[17] This study contradicts with the result of Johnson et al. (2002), where the result showed no significant differences between the FWS values measured with two methods. The FWS value of 2-7 mm was recommended.[18] Similarly, the study by Geerts et al. (2004) showed more reliability with caliper method than Willis method, the result being statistically significant however the clinical difference being negligible.[19] In the present study, caliper method was used as it was more convenient, quick, easily available, and affordable.

The range of freeway space values measured with head stabilization (1-6 mm) in the present study was found similar to that of the values observed in the study by Farias et al. in 2014 (1-7mm) with 74% of the total sample having the values between 2-4 mm.[4] However the FWS values in a study conducted by Vinnakota et al. in 2016 (1.24-3.67 mm)[20] and Gupta A et al. in 2015 (0.9-2.9 mm)[21] were found to be lower than the present study. This difference may be attributed to ethnic and geographical variation between study samples.

According to Miralles et al. (2001), the FWS value measurement is solely dependent upon the type of method used, where in their study the mean FWS values obtained after the phonetics method (3.39±1.13 mm) was greater than swallowing methods (1.53±0.52 mm).[22] In the present study, mean FWS value without head stabilization measured after swallowing and relaxing method (2.25±1.32 mm) is slightly greater than the above study.

The range of values of FWS measured with and without head stabilization in the present study was found to be higher than that of the values observed in the study by Shrestha K et al. in 2022 (2.11-2.58 mm) among the Nepalese population.[23] This difference may be contributed due to difference in sample size, variation in age groups, and skeletal relationship between study samples.

In the present study, group comparison showed that the average FWS value with head stabilization in male was 2.88±1.31 mm which was slightly higher than in female 2.6±1.2 mm. These results are similar to the results of the studies done by Shrestha K et al in 2022.[23] While contradicts with the result of Dosumu et al . in (2013), where female has higher FWS values than male[24], and study by Miralles et al. (2001) where the result was not statistically significant based on gender.[22]

The relationship between head muscles and dental occlusion has been thoroughly documented since 1950, when Brodie discovered that the mandible's resting position is influenced by the balance of muscles involved in chewing and the muscles in the back of the neck.[25] Goldstein et al. in 1984 used a kinesiograph to show that a forward head position is associated with a shift in the mandibular posture, resulting in a notable

reduction of the physiological freeway space due to the upward and backward movement of the mandible.[26]

Yamada et al. in 1999 studied how head posture affects habitual mandibular closing movements. They found that when the head is tilted forward, the closing path moves toward the maximum intercuspal position from the front, while tilting the head backward causes the closing path to approach this position from the back. A relationship between head posture and the stability of the closing movement has been noted. Specifically, tilting the head forward reduces the stability of the closing path, while tilting it backward enhances that stability.[27] However the result of the current study, lacks the sufficient evidence to support the above studies and falls short of evidence to show relationship of head posture to freeway space.

The limitations of this study include:

1. This study was conducted in the Department of Prosthodontics, CMC, CODS with 81 samples. A larger sample size would have been preferable.
2. It is a single center study and can be conducted in multi center in future.
3. Mandibular rest position can vary with emotion and fatigue which has to be taken into account in future studies.
4. This study was limited to class I skeletal pattern and Angle's class I malocclusion.
5. The sample size of male and female was not equal in the present study.
6. While the device's intra-observer reliability was high, its validity for influencing FWS remains unproven. The construction of head stabilizing device can be done in a more scientific way in further studies to come.
7. The age of patients in this study ranged from 18 to 35 years. It would have been preferable if the population had been more diverse in age.

CONCLUSION

Within the limitations of the present study and based on results obtained, following conclusions can be drawn:

1. There was no statistically significant difference between the freeway space value with and without head stabilization according to the result of present study.
2. The range of freeway space value after head stabilization is 1-6 mm and without head stabilization is 1-5 mm in dentulous patients.
3. There is no evidence to support that FWS values obtained after head stabilization is close to the recommended range of FWS compared to the values obtained without stabilizing head.
4. There is no effect of head posture in mandibular position according to the current study.

CLINICAL IMPLICATION

1. The freeway space values vary from person to person and can range from 1 mm to 6mm. Although most of the studies recommend 2-4 mm of FWS, space as minimum as 1mm and maximum as 6 mm can be provided during the fabrication of prosthesis in patients whose occlusion needs to be altered.
2. Using the head stabilization device while gauging FWS can be a more time consuming and tedious procedure. As there is no any significance of using head stabilization device in FWS, hence its use can be avoided.
3. According to this study, mandibular position is not affected by head posture; hence, it is appropriate to measure the freeway space value by conventional methods. Although this clinical significance is derived from the present study, further research with a wide range of populations is needed for evidence.

ACKNOWLEDGEMENTS

I would like to thank all my respected teachers and the staffs of Department of Prosthodontics of Chitwan Medical college and all the participants who agreed to participate.

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